**CHAPTER 13**

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* liquids flow by sliding over one another and takes the shape of its container and resist compressive forces. Both liquids and gases can flow, so both are called fluids.

**Pressure**

• pressure = force/area

• Although the weight of both blocks is the same, the upright block exerts greater pressure against the table.

**Pressure in a Liquid**

When you swim under water,

• The pressure you feel is due to the weight of air/water above you.

• deeper water = greater pressure.

• The pressure a liquid exerts depends on its depth and density of the liquid.

Liquid pressure = weight density × depth

• If we neglect atmospheric pressure,

o at twice the depth, the liquid pressure against the bottom is twice as great;

o at three times the depth, the liquid pressure is threefold; and so on.

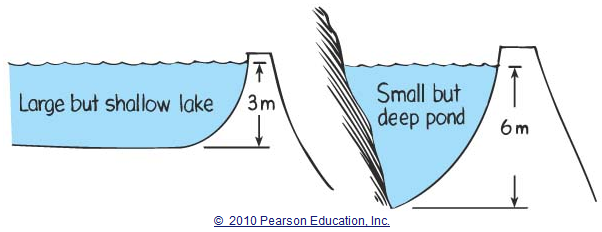
o Or, if the liquid is two or three times as dense, the liquid pressure is correspondingly two or three times as great for any given depth.

• the density of a liquid is the about the same at all depths except for changes due to temp.

• The total pressure of a liquid : weight density × depth + atmosphere pressure

• total pressure must be specified

• pressure does not depend on the amount of liquid present, only the depth.



• Volume is not the key—depth is. The average water pressure acting against the dam depends on the average depth of the water and not on the volume of water held back. The large, shallow lake exerts only one-half the average pressure that the small, deep pond exerts.

**Archimedes’ Principle**

• An immersed object is buoyed up by a force = weight of the fluid it displaces.

• If you stick your foot in water, it’s immersed. If immersion is total, you’re submerged

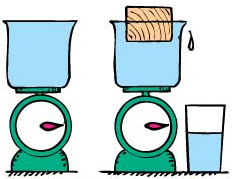
• an immersed object displaces 1 kilogram of fluid, the buoyant force acting on it is equal to the weight of 1 kilogram.

• This is because, at any depth, the container can displace no greater volume of water than its own volume.

• And the weight of this displaced water (not the weight of the submerged object!) is equal to the buoyant force.

• A liter of water occupies a volume of 1000 cm3, has a mass of 1 kg, and weighs 9.8 N. Its density may therefore be expressed as 1 kg/L and its weight density as 9.8 N/L. (Seawater is slightly denser, about 10.0 N/L).

• If we immerse it completely (submerge it), it will be buoyed up by a force equivalent to the weight of a full liter of water (1 kilogram of mass).

• If the container is fully submerged and doesn’t compress, the buoyant force will equal the weight of 1 kilogram of water at any depth.

If a 30-kilogram object displaces 20 kilograms of fluid upon immersion, its apparent weight will be equal to the weight of 10 kilograms (98 newtons). Note that, in Figure 13.13, the 3-kilogram block has an apparent weight equal to the weight of 1 kilogram when submerged. The apparent weight of a submerged object is its usual weight in air minus the buoyant force.

It makes no difference how deep the cube is placed because, although the pressures are greater with increasing depths, the difference between the pressure up against the bottom of the cube and the pressure down against the top of the cube is the same at any depth

Whatever the shape of the submerged body, the buoyant force is equal to the weight of fluid displaced.

Liquid pressure is the same for any given depth below the surface, regardless of the shape of the containing vessel. Liquid pressure = weight density × depth (plus the air pressure at the top).

• Pressure is depth dependent, not volume dependent, so we see that there is a reason why water seeks its own level.

• Roman aqueducts assured that water flowed slightly downhill from reservoir to city

• Some ancient pipe systems installed in Rome indicate that not all Romans believed that water couldn’t flow uphill.

• (fill a garden hose with water and holding the two ends at the same heigh and levels are equal.)( If one end is raised higher than the other, water will flow out of the lower end, even if it has to flow “uphill” part of the way)

• liquid pressure is exerted equally in all directions.

• Because a liquid can flow, the pressure is downward, sideways & upward.

• The bottom of a boat is certainly pushed upward by water pressure

• When liquid presses against a surface, there is a net force that is perpendicular to the surface. Although pressure doesn’t have a specific direction, force does.

• Components of the forces that are not perpendicular to the surface cancel each other out, leaving only a net perpendicular force at each point.

The forces of a liquid pressing against a surface add up to a net force that is perpendicular to the surface.

The force vectors act perpendicular to the inner container surface and increase with increasing depth.

**What Makes an Object Sink or Float?**

• buoyant force depends on volume of the object

• The buoyant force is = to weight of the volume of fluid displaced.

• Small objects displace small amounts = small buoyant forces.

• Large objects displace large amounts = larger buoyant forces.

• It is the volume of the submerged object—not its weight—that determines the buoyant force.

• The weight does affect floating.

• Whether an object will sink or float in a liquid depends on how the buoyant force compares with the object’s weight which depends on the object’s density.

• Consider these three simple rules:

1. An object more dense than the fluid in which it is immersed will sink.

2. An object less dense than the fluid in which it is immersed will float.

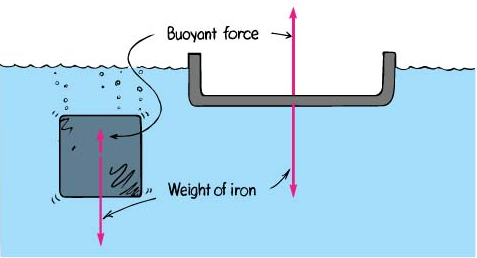
3. An object having a density equal to the density of the fluid in which it is immersed will neither sink nor float.

• diet soda float, and regular soda sink in water. What does this tell you about their relative densities?

• Wearing a life jacket increases volume while correspondingly adding very little to your weight. It reduces your overall density.

• For a submarine, weight, not volume, is varied to achieve the desired density. Water is taken into or blown out of its ballast tanks

• the overall density of a crocodile increases when it swallows stones. = swims lower in the water, thus exposing itself less to its prey



**Flotation**

An iron block sinks, while the same quantity of iron shaped like a bowl floats.

• Consider a 1-ton block of solid iron. Because iron is nearly eight times denser than water, it displaces only 1/8 ton of water when submerged, which is not enough to keep it afloat. Suppose we reshape the same iron block into a bowl. It still weighs 1 ton. But when we put it in water, it displaces a greater volume of water than when it was a block.

• When the buoyant force equals 1 ton, it will sink no farther.

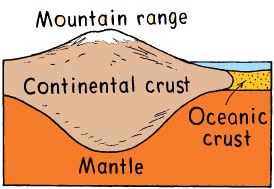
**principle of flotation:** When an object displaces a weight of fluid equal to its own weight, it floats. 

• If it displaces more, it rises; if it displaces less, it falls. If it displaces exactly its weight, it hovers at constant altitude.

•denser fluid = greater buoyant force than a less dense fluid.

• A ship, floats higher in salt water than in freshwater because salt water

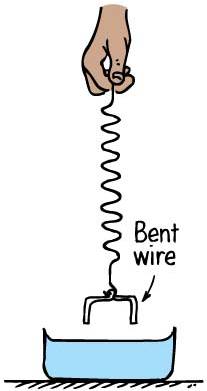
A floating object displaces a weight of fluid equal to its own weight



• **Pascal’s Principle**

**• a change in pressure at one part of an enclosed fluid will be transmitted undiminished to other parts.**

**• force exerted on the left piston increases the pressure in the liquid and is transmitted to the right piston.**

**• if the pressure of city water is increased at the pumping station by 10 units of pressure, the pressure everywhere in the pipes of the connected system will be increased by 10 units of pressure**

**• Fill a U-tube with water and place pistons at each end,. Pressure exerted against the left piston will be transmitted throughout the liquid and against the bottom of the right piston.**

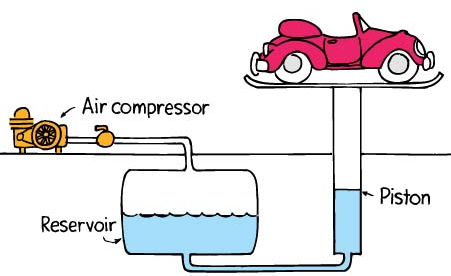
**• The pressure that the left piston exerts against the water will be exactly equal to the pressure the water exerts against the right piston.**

**• Since there is 50 times the area, 50 times as much force is exerted on the larger piston. Thus, the larger piston will support a 500-kg load—fifty times the load on the smaller piston!**

**• Blaise Pascal is remembered scientifically for hydraulics**

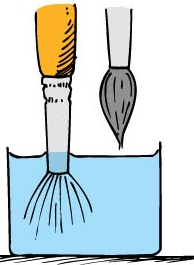
**• The input force multiplied by the distance moved by the smaller piston is equal to the output force multiplied by the distance moved by the larger piston; this is one more example of a simple machine operating on the same principle as a mechanical lever.**

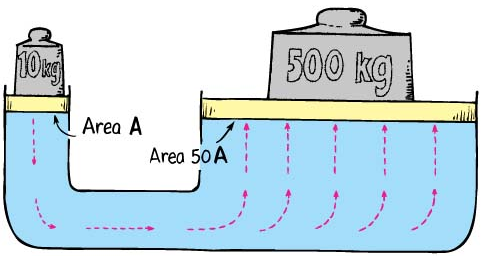
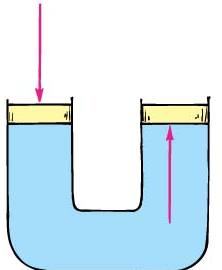
**• Pascal’s principle applies to all fluids, whether gases or liquids.**

**• Hydraulics is employed by modern devices ranging from very small to enormous. Note the hydraulic pistons in almost all construction machines where heavy loads are involved**

• **Surface Tension**

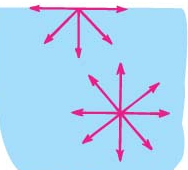
• This contractive tendency of the surface of liquids

• When the bent wire is lowered into the water and then raised, the spring will stretch because of surface tension.

• When the brush is taken out of the water, the hairs are held together by surface tension.

• accounts for the spherical shape of liquid drops.

• Sphere- the shape having the least surface area.

• the mist and dewdrops on spider are nearly spherical blobs. (The larger they are, the more that gravity flattens them.)

• Surface tension is caused by molecular attractions.

• each molecule is attracted in every direction by neighboring molecules, resulting in no tendency to be pulled in any specific direction.

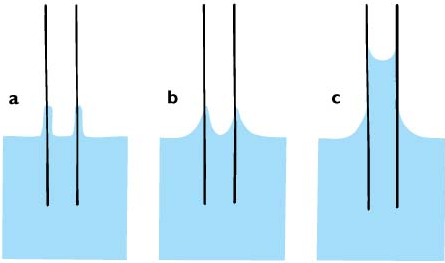
• A molecule on the surface of a liquid is pulled only by neighbors on each side and downward from below; there is no pull upward

• These molecular attractions thus tend to pull the molecule from the surface into the liquid, and this tendency minimizes the surface area.

• The water surface sags like a piece of plastic wrap, which allows certain insects, such as water striders, to run across the surface of a pond.

• The surface tension of water is greater than that of other common liquids,

• pure water has a stronger surface tension than soapy water. We can see this when a little soap film on the surface of water is effectively pulled out over the entire surface. This minimizes the surface area of the water. The same thing happens for oil or grease floating on water. Oil has less surface tension than cold water, and it is drawn out into a film covering the whole surface. But hot water has less surface tension than cold water because the faster-moving molecules are not bonded as tightly. This allows the grease or oil in hot soups to float in little bubbles on the surface of the soup. When the soup cools and the surface tension of the water increases, the grease or oil is dragged out over the surface of the soup. The soup becomes “greasy.” Hot soup tastes different from cold soup primarily because the surface tension of water in the soup changes with temperature.



• **Capillarity**

• The rise of a liquid in a fine, hollow tube or in a narrow space is capillarity.

• Bubble Master Tom Noddy blows bubbles within bubbles. The large bubble is elongated due to blowing, but it will quickly settle to a spherical shape due to surface tension

Water molecules stick to glass more than to each other. The attraction between unlike substances such as water and glass is called adhesion. The attraction between like substances, molecular stickiness, is called cohesion.

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how oil soaks upward in a lamp wick and water soaks into a bath towel when one end hangs in water.

• Capillary action brings water to the roots of plants and carries sap and nourishment to high branches of trees.